Remarks

Claims 164, 166, 170-174 and 196-229 are pending in the Application.

Claims 164, 166, 170-174 and 196-229 are rejected.

I. REJECTIONS UNDER 35 U.S.C. § 102/ § 103 OVER *KIANG*

In the Advisory Action, Examiner has maintained the rejection of Claims 164, 166, 170-174 and 199-220 under 35 U.S.C. § 102(a) and (b) as being anticipated by, or in the alternative, under 35 U.S.C. § 103(a) as obvious over Kiang *et al.* "Structural Modification of Single-Layer Carbon Nanotubes with an Electron Beam," *J. Phys. Chem.* **1996**, 100, 3749-3752, ("*Kiang*"). Advisory Action, at 1; Final Office Action, at 2.

Applicant respectfully maintains its traversal of this rejection as articulated in Applicant's 1.116 Amendment, and incorporates its prior bases for doing so in this Supplemental 1.116 Amendment. In the Advisory Action, and when continuing its rejections of the claims, Examiner indicated that "Applicant should point to where in the specification the uniformity of cutting is firmly established." Advisory Action, at 1.

Accordingly, Applicant responds to Examiner's inquiry and respectfully points to the following citations in the Specification, which firmly establish the uniformity of cut single-wall carbon nanotubes (*i.e.*, cut single-wall carbon nanotubes having a substantially similar length).

> In another embodiment, a method for producing tubular carbon molecules of about 5 to 500 nm in length is also disclosed. The method includes the **steps of cutting single-wall nanotube containing-material to form a mixture of tubular carbon molecules having lengths in the range of 5-500 nm** and **isolating a fraction of the molecules having substantially equal lengths.** The nanotubes disclosed may be used, singularly or in multiples, in power transmission cables, in solar cells, in batteries, as antennas, as molecular electronics, as probes and manipulators, and in composites.

(Application, at 4, *ll.* 1-8, emphasis added)

> Alternatively, bucky paper may be made up of **nanotubes which are homogeneous in length** or diameter and/or molecular structure due to fractionation as described hereinafter.

(Application, at 23, *ll.* 19-21, emphasis added)

> Preparation of **homogeneous populations of short carbon nanotube molecules may be accomplished by cutting and annealing (reclosing) the nanotube pieces followed by fractionation.** The cutting and annealing processes may be carried out on a purified nanotube bucky paper, on felts prior to purification of nanotubes or on any material that contains single-wall nanotubes. When the cutting and annealing process is performed on felts, it is preferably followed by oxidative purification, and optionally saponification, to remove amorphous carbon. Preferably, the starting material for the cutting process is purified single-wall nanotubes, substantially free of other material.
>
> The short nanotube pieces can be cut to a length or selected from a range of lengths, that facilitates their intended use. For applications involving the individual tubular molecules per se (e.g., derivatives, nanoscale conductors in quantum devices, i.e., molecular wire), the length can be from just greater than the diameter of the tube up to about 1,000 times the diameter of the tube. Typical tubular molecules will be in the range of from about 5 to 1,000 nanometers or longer. For making template arrays useful in growing carbon fibers of SWNT as described below, lengths of from about 50 to 500 nm are preferred.
>
> Any method of cutting that achieves the desired length of nanotube molecules without substantially affecting the structure of the remaining pieces can be employed. The preferred cutting method employs irradiation with high mass ions. In this method, a sample is subjected to a fast ion beam, e.g., from a cyclotron, at energies of from about 0.1 to 10 giga-electron volts. Suitable high mass ions include those over about 150 AMU's such as bismuth, gold, uranium and the like.
>
> **Preferably, populations of individual single-wall nanotube molecules having homogeneous length are prepared starting with a heterogeneous bucky paper and cutting the nanotubes in the paper using a gold (Au^{+33}) fast ion beam.**

(Application, page 25, *l.* 9 to page 26, *l.* 5, emphasis added)

> The **cleaned nanotube material may be cut into 50-500 nm lengths, preferably 100-300 nm lengths**, by this process. The resulting pieces may form a colloidal suspension in water when mixed with a surfactant such as Triton X-100™ (Aldrich, Milwaukee, WI). These stable suspensions permit a variety of manipulations such as sorting by length using field flow fractionation, and electrodeposition on graphite followed by AFM imaging.
>
> In another embodiment, SWNTs can be cut using electron beam cutting apparatus in the known manner.
>
> **Combination of the foregoing cutting techniques can also be employed.**
>
> **Homogeneous populations of single-walled nanotubes may be prepared by fractionating heterogeneous nanotube populations after annealing.** The annealed nanotubes may be disbursed in an aqueous detergent solution or an organic solvent for the fractionation. Preferably the tubes will be disbursed by sonication in benzene, toluene, xylene or molten naphthalene. The primary function of this procedure is to separate nanotubes that are held together in the form of ropes or mats by van der Waals forces. **Following separation into individual nanotubes, the nanotubes may be fractionated by size** by using fractionation procedures which are well known, such as procedures for fractionating DNA or polymer fractionation procedures.

(Application, at 28, *ll.* 4-23, emphasis added)

> In general the **length**, diameter and helicity of these molecules **can be controlled to any desired value.** Preferred lengths are up to 10^6 hexagons; preferred diameters are about 5 to 50 hexagon circumference; and the preferred helical angle is 0° to 30°.
>
> **Preferably, the tubular molecules are produced by cutting** and annealing nanotubes of predominately arm-chair (n,n) configuration, which may be obtained by purifying material produced according to the methods discussed above.

(Application, at 29, *ll.* 21-27, emphasis added)

Example 5. Procedure for cutting SWNT into tubular carbon molecules

Bucky paper (~100 microns thick) obtained by the filtration and baking of purified SWNT material as described in Example 1 was exposed to a 2 GEV beam of Au^{+33} ions in the Texas A&M Superconducting Cyclotron Facility for 100 minutes. The irradiated paper had 10-100 nm bullet holes on average every 100 nm along the nanotube lengths. The irradiated paper was refluxed in 2.6 M nitric acid for 24 hours to etch away the amorphous carbon produced by the fast ion irradiation, filtered, sonicated in ethanol/potassium hydroxide for 12 hours, refiltered, and then baked in vacuum at 1100°C to seal off the ends of the cut nanotubes.

The material was then dispersed in toluene while sonicating. The resulting tubular molecules which averaged about 50-60 nm in length were examined via SEM and TEM.

(Application, at 75, *ll.* 8-20)

In another embodiment, a method for continuously growing a macroscopic carbon fiber comprising at least about 10^6 single-wall nanotubes in generally parallel orientation is disclosed. In this method, a macroscopic molecular array of at least about 10^6 tubular carbon molecules in generally parallel orientation and having substantially **similar lengths** in the range of from about 50 to about 500 nanometers is provided.

(Application, at 5, *ll.* 1-6, emphasis added)

In another embodiment, a macroscopic molecular array comprising at least about 10^6 single-wall carbon nanotubes in generally parallel orientation and **having substantially similar lengths** in the range of from about 5 to about 500 nanometers is disclosed.

(Application, at 5, *ll.* 13-16, emphasis added)

In another embodiment, a method for forming a macroscopic molecular array of tubular carbon molecules is disclosed. This method includes the steps of providing at least about 10^6 **tubular carbon molecules of substantially similar length in the range of 50 to 500 nm;** introducing a linking moiety onto at least one end of the tubular carbon molecules; providing a substrate coated with a material to which the linking

> moiety will attach; and contacting the tubular carbon molecules containing a linking moiety with the substrate.

(Application at 4, *ll.* 9-15, emphasis added)

There is no such teaching or suggestion in *Kiang* as to the above; nor is there any teaching or suggestion in *Kiang* that the cut single-wall carbon nanotubes of *Kiang* have a substantially similar length. To the contrary, *Kiang* discloses cutting nanotubes with no suggestion or motivation to cut them so that their resulting lengths would be substantially similar. There is likewise no teaching or suggestion in *Kiang* how cut nanotubes were to be isolated such that uniform cut single-wall carbon nanotubes could be utilized in a quantum device (as claimed in Claim 164 and its dependent Claims 199-202); an integrated circuit (as claimed in Claim 166 and its dependent Claims 203-205); an RF shielding device (as claimed in Claim 170 and dependent Claims 206-208); a microwave absorbing material (as claimed in Claim 171 and dependent Claims 209-211); a hydrogen storage device (as claimed in Claim 172 and dependent Claims 212-214); a battery (as claimed in Claim 173 and dependent Claims 215-217), and a fuel cell (as claimed in 174 and dependent Claims 218-220).

Nor does *Kiang* teach or suggest that the "purified and cut single-wall carbon nanotubes have a substantially similar length." Therefore, again, *Kiang* does not teach or suggest all the limitations of the claims. Applicant also notes that *Kiang* provides no teaching, disclosure, or even a suggestion that the cut single-wall carbon nanotubes have a substantially similar length. Furthermore, there is no suggestion or motivation in *Kiang* or in the knowledge generally available to one of ordinary skill in the art, to modify *Kiang* in order to arrive at the elements of these claims of the instant invention.

Therefore, in view of the above, and in view of Applicant's 1.116 Amendment, Applicant again respectfully requests the Examiner to withdraw the rejection of Claims 164, 166, 170-174 and 199-220 under 35 U.S.C. § 102(a) and (b) as being anticipated by, or in the alternative, under 35 U.S.C. § 103(a) as obvious over *Kiang*.

II. REJECTIONS UNDER 35 U.S.C. §103(a) OVER *KIANG*

Examiner has also maintained his rejection of Claims 170-174, 196-198 and 206-229 under 35 U.S.C. § 103(a) as being unpatentable over *Kiang et al.* Advisory Action, at 1; Final Office Action, at 2.

Applicant respectfully maintains its traversal of the rejection, as articulated in Applicant's 1.116 Amendment, and incorporates its prior bases for doing so in this Supplemental 1.116 Amendment. Again, Applicant has pointed out citations in the Specification, listed above, which firmly establish the uniformity of cut single-wall carbon nanotubes (*i.e.*, cut single-wall carbon nanotubes having a substantially similar length).

The reasons as to why each of these claims is not obvious in view of *Kiang* are discussed above, as well as in Applicant's 1.116 Amendment, which response is again incorporated herein.

Therefore, again in view of the foregoing, Applicant respectfully requests the Examiner to withdraw the rejection of Claims 170-174, 196-198 and 206-229 under 35 U.S.C. § 103(a) as obvious over *Kiang*.

III. REPLY TO EXAMINER'S ADDITIONAL REMARKS IN FINAL OFFICE ACTION

As noted in Applicant's 1.116 Amendment, the Examiner also contends that "*Kiang* teaches a homogeneous product." Final Office Action, at 2. Applicant respectfully disagrees, and has previously pointed out that: "There is no teaching or suggestion in *Kiang* that the cut single-wall carbon nanotubes of *Kiang* have a substantial similar length. To the contrary, *Kiang* discloses cutting nanotubes with no suggestion or motivation to cut them so that the lengths would be a substantially similar length." Applicant's 1.116 Amendment, at 13. Applicant does not believe Examiner expressly responded to this in the Advisory Action.

IV. CONCLUSION

As a result of the foregoing, it is asserted by Applicant that the Claims in the Application are now in a condition for allowance, and respectfully requests allowance of such Claims.

Applicant believes that it has concurrently herewith paid all fees required with this amendment and that no further fees are due. However, should any further fees be required, the Commissioner is authorized to charge such fees to Deposit Account No. 06-1050. Please reference Attorney Docket No. 21753-012014.

Applicant respectfully requests that the Examiner call Applicant's attorney at number listed below if the Examiner believes that such a discussion would be helpful in resolving any remaining problems.

Respectfully submitted,
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